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ABSTRACT

This study investigated the effects of certain types of science experiences ("hands-on" versus "non-hands-on") on the development of selected cognitive abilities as inferred by performance on Piagetian-type tasks. Thirty-six students from first, third, and fifth grades were randomly chosen as subjects. Eighteen of the students from each grade level had "hands-on" science experience, while the other 18 students were classified as "non-hands-on" students. Six Piagetian-type tasks were individually administered to each subject. Analysis of the data indicates no differences in the cognitive abilities of the two groups, as measured by the six tasks described. The author suggests three possible reasons for this finding. (MK)

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Effects of Science Instructional Method Upon Cognitive Development

by

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SE 030 107

Problem Statement

The primary purpose of this investigation was to determine what effects, if any, certain types of experience - "hands-on" versus "non-hands-on" - have on the development of selected cognitive abilities as inferred by performance on Piagetian-type tasks. In order to accomplish this, a group of Piagetian-type tasks, each designed to assess the presence or absence of a specific cognitive structure, were presented to a sample of children. Their responses to each one of these tasks were categorized utilizing a set of criteria established by this researcher, and based on descriptions provided by Piaget, Inhelder and Szeminska (1, 2, 3).

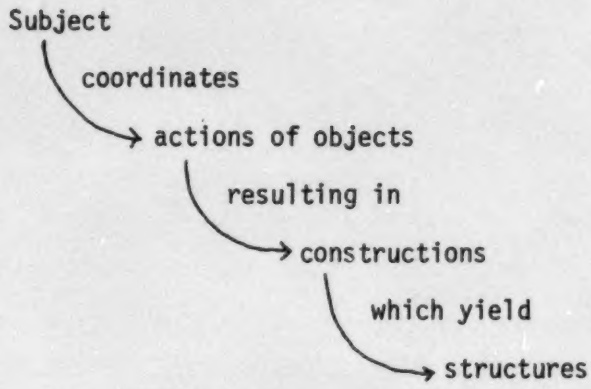
Introduction

A variety of "hands-on" curricula are available for incorporation into today's classrooms. These curricula are purported to be of greater value in fostering the development of cognitive processes that those curricula utilizing other approaches, such as lecture or reading or demonstration, or a mixture of the aforementioned approaches.

The utilization of a "hands-on" approach is often predicated on the basis of Piaget's description of cognitive development. More specifically it is derived from Piaget's contention that experience is one of the factors mediating cognitive development, the other three factors being maturation, social transmission, and equilibration.

The role of action is emphasized in Piaget's description. To know an object a subject must act upon it, and thus transform it, that is, the subject must displace, connect, combine, take apart and reassemble it.

Knowledge therefore is constantly linked with actions. The following sequential diagram illustrates the preceding sequence:



If this scheme is accurate then one would expect a child having greater opportunity to act on objects to have more highly developed cognitive structures.

Of the four factors suggested to have an effect in cognitive development, one, namely experience, lends itself to measurement. To date very little empirical evidence has been proferred in order to establish to what extent the manipulation of objects actually facilitates the attainment of cognitive structures. Furthermore, numerous research findings in science education (4, 5, 6, 7, 8) indicate that "hands-on" activity might be important in some instances and appears to make no difference in other instances, and that this question has not been resolved.

Procedure

Subjects. The sample for this study was drawn from two groups and thus divided into subsamples. These two groups were similar with respect to socio-economic factors. The two populations did differ with respect to exposure to the independent variable of "hands-on" science. One group came from three elementary schools in Tempe, Arizona. It was determined from the teacher and administrators that the children in this group had no "hands-on" science. They had either witnessed science demonstrations, read from a science textbook, or had no science experience whatsoever. The other group came from three elementary schools in a Phoenix, Arizona school district. It was determined that the

students in this population had had "hands-on" science experience. The teachers working with this second group had been trained[1] in use of "hands-on" science experience, and were in fact utilizing the Science Curriculum Improvement Study program's materials and were using suggested SCIS strategies. It was determined that this group of children had experienced "hands-on" science. This had been ascertained by individual interview and questionnaire procedures which were designed to assess the effectiveness of their prior training experience. Each subject had been exposed to "hands-on" science for a minimum of one-half a school year. The subjects for the two subsamples were randomly selected from first, third, and fifth grades. Thirty-six subjects were selected from each grade level, eighteen from the "hands-on" population, and eighteen from the "non-hands-on" population. The average age at each grade level at the time of interviewing was first - 6:6, third - 8:7, and fifth - 10.9.

Measures. Six Piagetian-type tasks were individually administered to each of the subjects. These six tasks were derived from the following groupings: ITo_1 (Partition of Sets and Addition of Subsets); ITo_2 (Reciprocity of Proximities); ITo_4 (One-to-One Multiplication of Elements); ITo_5 (Order of Placement); ITo_6 (Symmetrical Interval Relations); and ITo_8 (One-to-One Multiplication of Relations).

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1 This training was brought about by the Portal School Program at Arizona State University. The Portal School Program was designed to introduce "hands-on" programs - ISCS, ESS, SCIS, etc. - to Arizona teachers. This program was N.S.F. supported for two years, 1974-1975 and 1975-1976.

The task used to examine grouping ITo_4 had to be designed for this research since there were no clear references in the literature. It is the contention of this investigator that performance on this set of Piagetian-type tasks gives an indication of an individual's overall cognitive development. This contention is based on Piaget's hypothesis (3) that certain of the logical structures develop in parallel with some of the infralogical structures. This has been verified to some extent (9,10,11). Therefore, an assessment of the topological groupings, which are part of the infralogical sub-system, will also provide indications of the degree of development of the logical sub-system. Each task was designed to ascertain whether a subject possessed the cognitive ability described by a particular grouping. If a subject successfully completed a task, that is, gave acceptable responses to all parts, it was inferred that the subject possessed that grouping.

The concept of groupings is central to Piaget's explanation of how thought develops during the concrete operational stage and how the child is able to operate in his world and understand it. These groupings are considered to be models of how people think in several areas of intellectual endeavor, and attempt to symbolically express what is implied in a child's actions.

The tasks, with the exception of the task used to examine grouping ITo_4 (designed specifically for this research by this investigator), were designed on the basis of information provided by Piaget and Inhelder and Szeminska (1,2,3). These descriptions were not complete, and therefore the tasks used in this investigation are different than tasks used elsewhere.

Administration of Tasks. The tasks were administered in a randomized order. Each task was scored on the basis of pre-determined criteria derived from the literature and the results of a prior study (9). In order to provide a reliability check of the scoring of the tasks, a second person who was knowledgeable about the work of Piaget, with previous experience in scoring and evaluation of interviews, scored a randomized sample of the data to assure consistency in the scoring of task responses on the part of the investigator. Another individual, who due to his professional involvement with Piagetian-type research, was considered an expert, responded that the tasks appeared to be measures of the groupings they were designed to assess.

Each one of these tasks permitted the subject being interviewed to interact with the objects (either overtly or representationally) and to respond to questions regarding his actions upon the objects. Most of the protocols required that the subject supply an acceptable reason for a choice.

Results

Scoring. For the purposes of the analyses used in this study only those who completed each part of a task without any errors were given a "pass." Otherwise, the subject was given a "fail."

Table 1 and 2 provide the combined totals as well as individual grade level totals of subjects passing each task in the Phoenix (P) and Tempe (T) Elementary Schools samples respectively.

TABLE 1

NUMBER OF SUBJECTS PASSING EACH TASK - HANDS-ON CLASSES

Grade Level	N	Task Number					
		ITo_1	ITo_2	ITo_4	ITo_5	ITo_6	ITo_8
1	18	3	2	1	7	1	6
3	18	6	10	0	15	11	15
5	18	14	16	7	16	13	17
TOTAL	54	23	28	8	38	25	38

TABLE 2

NUMBER OF SUBJECTS PASSING EACH TASK - NON-HANDS-ON CLASSES

Grade Level	N	Task Number					
		ITo_1	ITo_2	ITo_4	ITo_5	ITo_6	ITo_8
1	18	3	3	0	10	1	9
3	18	12	10	4	17	8	17
5	18	14	17	10	18	17	18
TOTAL	54	29	30	14	45	26	44

Data Analyses. The null hypothesis that there was no difference in performance on each of the Piagetian-type tasks between samples derived from a "hands-on" population and a "non-hands-on" population was tested. The X^2 for two independent samples procedure (12) was utilized to test this hypothesis. Table 3 provides the X^2 values obtained for each task using this procedure.

TABLE 3

COMPARISON OF PERFORMANCE ON TOPOLOGICAL TASKS BETWEEN HANDS-ON AND NON-HANDS-ON CLASSES

	Tasks Number					
	ITo_1	ITo_2	ITo_4	ITo_5	ITo_6	ITo_8
X^2 VALUE	0.93	0.04	1.42	1.87	0.00	0.91

P = .05

X^2 = 3.84

The null hypothesis was retained at the .05 level of significance, for all the topological tasks: ITo_1; ITo_2; ITo_4; ITo_5; ITo_6; and, ITo_8.

These findings indicate that there was no significant statistical difference in performance on the Piagetian-type tasks between the two samples.

Since no evidence of difference in performance on the dependent variables was found there is no basis upon which to reject the null hypothesis.

Discussion and Implications

A few explanations can be offered as to why there appears to be no differences in selected cognitive abilities, as measured by the Piagetian-type tasks, between the two groups interviewed. These reasons, if at all viable, either acting singly or in conjunction with one-another might have underlaid the lack of difference in performance. A few plausible explanations are suggested in the following discussion.

(a) There is the possibility that the tasks which were used in this study to assess specific cognitive abilities did not measure these abilities, and therefore the findings of no difference in performance on tasks does not necessarily mean that there is no difference in cognitive development.

(b) Another possibility which may have contributed to the finding of no difference between groups is that the "hands-on" group's duration of exposure to the treatment (access to and the use of materials) was relatively short, that is only one-half of a school year. Thus, if there was an affect it may have been minimal and was not detected with the instruments employed.

(c) Finally, and most importantly with respect to this investigation, is the possibility that "hands-on" exposure makes little, or no difference, with respect to the process of cognitive development. Based on the considerations offered, the question of whether or not a "hands-on" science experience does promote the development of cognitive structures remains unresolved. Since so many of today's science curricula do purport to be higher value due to the incorporation of "hands-on" experiences as compared to programs which do not offer such experiences, it is imperative that further research be undertaken in order to resolve this question.

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